Speciation of Smelter Contaminated Soils using XAFS Spectroscopy

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Introduction: Soils contaminated as a result of Zn smelting operations from the historic Palmerton smelting facility were characterized using XAFS spectroscopy coupled with SEM, XRD and sequential extraction techniques. Surface (0-5 cm) and subsurface (5-25 cm) samples were collected from a non-vegetated region and the pH was measured and total metal concentrations determined using an acid extraction technique. The surface soil had a Zn concentration of 6196 ppm with a pH of 3.19 while the subsurface sample had a Zn concentration of 900 ppm and a pH of 3.86. XRD analysis indicated the main Zn mineral phase in the surface soil was franklinite (Zn-Fe oxide), while the subsurface soil contained more amorphous materials not identifiable using this approach. XAFS analyses were performed on both soils as well as a variety of Zn-bearing mineral phases and synthesized Zn sorption samples to aid in identifying Zn species. Using linear combinations of model compound spectra to fit the data, EXAFS revealed the Zn distribution in the surface soil to consist of approximately 85% franklinite and 15% sphalerite (Zn sulfide). The SEM data confirms these findings as Zn was found in discrete phases associated with Fe and S. Zn speciation in the subsurface sample was dominated by sorption complexes rather than mineral phases. Linear combination fitting of Zn sorption sample spectra revealed that approximately 50% of Zn was sorbed to Fe oxides, 30% sorbed to Mn oxides, 15% sorbed to aluminosilicates, and the remainder present as franklinite. These results show the utility of EXAFS in speciating metal-contaminated soils beyond what other techniques alone can achieve.